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THESIS

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by

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by

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Lieutenant, United States Navy
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ABSTRACT

Over 225 aircraft reconnaissance missions (1966–1972) into eastern North Pacific tropical (EASTROPAC) cyclones (tropical storms and hurricanes only) are computer processed and analyzed to present a composite view of the near-center cyclone structure. Radially-averaged profiles of D-values, isotherms, and isotachs are related to similar information from North Atlantic and western North Pacific tropical cyclones. A two-dimensional analysis of these parameters does not appear advantageous at this time due to the scarcity and distribution of data.

The analyses qualitatively indicate that EASTROPAC cyclones are small in horizontal extent while relatively intense for their size, the latter feature comparing favorably to the average North Atlantic tropical cyclone. Maximum warming occurs within the radius of maximum wind (which averages 24 n mi) at lower levels with cyclone-induced warming evident to a radius of 90 n mi at upper levels. Other features are shown and suggestions for future research discussed.

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ACKNOWLEDGEMENTS

The author wishes to express his appreciation to the Naval Weather Service Environmental Detachment, National Climatic Center, Asheville, North Carolina, for providing copies of the aircraft reconnaissance worksheets for the years 1966–1972; and to the 9th Weather Wing, McClellan Air Force Base, California, Fleet Weather Facility, Alameda, California, and National Weather Service Forecast Office, Redwood City, California for additional reconnaissance data; to the meteorological technicians of the Department of Meteorology, Naval Postgraduate School, Monterey, California for their help in extracting the data; to my thesis advisor Dr. Robert J. Renard, NPS, for his help and encouragement throughout this study; and to Dr. Russell L. Elsberry, NPS, for his comments and critique.

I. BACKGROUND AND OBJECTIVES

Historically, the forecasting of intensity and movement of cyclones generated in the eastern tropical North Pacific Ocean (EASTROPAC) area has involved the use of techniques employed on tropical cyclones of the North Atlantic and western North Pacific regions. Simpson and Frank (1969) noted that disturbances which have their origin in the Atlantic play a significant role in triggering eastern Pacific tropical storms. Therefore, the EASTROPAC area should be considered a westward extension of the North Atlantic/Caribbean tropical cyclone area. Serra (1971) indicated the real problem when stating that inadequate data existed for the study of EASTROPAC cyclones. Therefore, he suggested that identification and forecast procedures used in the Atlantic be applied in the EASTROPAC area as an interim measure.

Hansen (1972) conducted a study which developed a tropical—cyclone climatology for the EASTROPAC region. In his report, significant differences in frequency, size, and behavior were noted to exist between EASTROPAC cyclones and those generated in the North Atlantic and western North Pacific regions. In particular, he noted that: i) the frequency of occurrence of EASTROPAC cyclones per unit area and time is greater than that of any other region in the

world, ii) on the average, EASTROPAC cyclones are about one-half the size of their western North Pacific counterparts, and iii) the vector motions of EASTROPAC cyclones show small deviation about the climatological means.

Shea and Gray (1972) published a report in which a composite technique, involving aircraft reconnaissance observations, was used to analyze the inner structure of North Atlantic hurricanes. Pou (1973), surmising that there existed sufficient aircraft reconnaissance data to attempt a similar analysis in the EASTROPAC area, devised computer software for decoding and analyzing the reconnaissance data in composite form. However, the main purpose of Pou's research was to design and establish adequate processing and analysis programs using computer methods. His emphasis was on the formulation of a prototype program and not on extensive analysis of EASTROPAC cyclones.

The objective of this report, which is a sequel to Pou's work, became two-fold. The first portion was to collect and assemble all available aircraft reconnaissance data made into EASTROPAC cyclones. The second part was to analyze this data, using the composite approach, to determine if the inner structure of EASTROPAC cyclones differed significantly from the structure of tropical cyclones found elsewhere. Such an analysis might be used in partial explanation of the EASTROPAC climatological values and their relation to other tropical cyclone areas, as researched by Hansen (1972). In any case, the ultimate

goal of the study is improvement in forecasting the intensity, movement, and structure of the EASTROPAC cyclone.

II. DATA

A considerable portion of the project time was devoted to search and assemblage of all available aircraft reconnaissance data relating to EASTROPAC cyclones. Initially, data were made available through the services of the Naval Weather Service Environmental Detachment, National Climatic Center, Asheville, North Carolina, and Fleet Weather Facility, Alameda, California. However, since aircraft units did not always forward completed reconnaissance worksheets to Asheville, historical records of past flights into EASTROPAC cyclones were not complete. This was especially evident when searching for data collected more than three years ago.

Thus, a search was made of periodicals known to contain annual EASTROPAC cyclone summaries. The Annex to the Annual Typhoon Report issued by Fleet Weather Central/Joint Typhoon Warning Center (FWC/JTWC), Guam and the March issues of the Monthly Weather Review and Mariner's Weather Log contain summaries of this nature. The reconnaissance flights discussed in the texts of each of the three sources were cross-checked yielding a relatively complete count of flights.

A comparison of data on hand with the above list of flights indicated that some data were still not in hand.

At this juncture, communication was established with Fleet Weather Facility, Alameda, California, the 9th Weather Wing, McClellan Air Force Base, California; and the National Climatic Center, Asheville, North Carolina, in a search for existent but missing data. Further, a visit to the National Weather Service Office in Redwood City, California proved fruitful in locating missing data. Tables I and II indicate the data base assembled in the manner described. As evidenced by Table I, the search process uncovered an amount of data heretofore not known to exist (1966, 1968, 1971 and 1972). As a consequence of the data search, the data base (1966—1972) is about 90% complete, the major exception being logs from twelve 1969 Navy flights made by EC—121 units operating out of Point Mugu, California. It should be noted that these planes did not normally fly weather missions, although the crews included experienced weather observers. The final data set, which contained approximately 4500 individual reconnaissance reports, was computer processed through a program written by Pou (1973).

III. ANALYSIS

In the analysis phase, only those reconnaissance reporting points lying within 100 nautical miles of the cyclone center were utilized. This resulted in a selection of 731 out of the original 4500 points.

To obtain an initial approximation of the fields to be studied, radial arcs were constructed at 10-mile increments from the center of the composite cyclone to a distance of 100 nautical miles. Table III indicates the different parameter fields calculated and the number of data points used in the calculation of each field. Where sufficient composite data existed, radial profiles were constructed.

D-values (with respect to the United States Standard Atmosphere), isotach, isotherm, and isodrosotherm values were calculated as radial averages over a distance of five miles either side of the calculation point, for both the tropical storm and hurricane stages. Table IV indicates the number of values used in the averages for each radial distance and for each composite profile.

In order to put the composite radial profiles in proper perspective, the individual-flight D-value profiles for various isobaric surfaces and cyclone stages are shown first. See Figures 1-4.

Since the primary mission of reconnaissance flights into EASTROPAC cyclones was to ascertain position data essential to the operational forecast, and not to analyze its vertical structure, more than one dropsonde sounding per flight was made only 20 percent of the time. For these cases, D—values were plotted against radial distance from the center of the composite cyclone. The points were then joined with straight lines yielding linear D—value gradients between observation points.

The composite D—value profiles for hurricane and tropical storm cases at 1000, 850, 700, 500 and 300 mb are shown in Figures 5 and 6, respectively. Certain of the radial values appear meteorologically unlikely, as for example the 700—, 850—, and 1000—mb profiles in the 40—60 radial band. For these problem areas, linearly calculated D—value gradients from the individual but similar cyclones (i.e. D—values and maximum surface winds subjectively evaluated to be similar to those along radii bracketing the one in question) were substituted for the questionable composite gradients in Figures 5 and 6. In this manner, the 40 — 80 mile band of the 700—mb hurricane profile in Figure 5 was adjusted using information from Figure 1. In addition, the 40—60 (0—20) mile radii of the 850—mb (1000—mb) profile (Figure 5) was modified, using values from Figures 3 and 4. The 500—mb and 300—mb profiles of Figure 5 were not adjusted due to insufficient individual cyclone data.

The unmodified composite tropical storm D-value radial profiles shown in Figure 6 were also modified in a manner similar to that described above. In particular, the 0-10 mile and 60-90 mile bands of the 700-mb profile were adjusted using 700-mb linear gradients from Figure 2; the 0-10 mile and 50-60 mile bands of the 850-mb profile in Figure 6 were modified using Figure 3; and the 0-10 mile band of the 1000-mb surface was adjusted using Figure 4. The remainder of the 1000-mb profile and the 300-mb and 500-mb profiles of Figure 6 were not adjusted due to lack of sufficient individual profiles.

Figures 7 and 8 are the resulting modified D-value profiles for the hurricane and tropical storm stages, respectively. A discussion of the modified D-value analyses, as compared with the results of Shea and Gray (1972) for the North Atlantic area follows in the next section.

As Table III indicates,the 3000-meter level was the only level that yielded substantial isotach data. Figure 9 illustrates the results of the composite isotach profiles for both the hurricane and tropical storm stages in EASTROPAC as compared to the results found by Shea and Gray (1972) for tangential winds in the North Atlantic area.

Table III also indicates that substantial amounts of isotherm data exist only at the 700-mb level. Figure 10 represents the 700-mb composite temperature profiles for

both the hurricane and tropical storm stages. The 300-mb composite profiles were also included even though there was a paucity of data at that level. The 750-mb and 650-mb profiles found in Figure 10 represent adjusted North Atlantic temperature calculations made by Shea and Gray (1972). A discussion of Figures 9 and 10 is found in Section IV.

A more detailed plan-view (vice profile) depiction of the pressure, wind and temperature fields was obtained through a numerical processing program devised by Pou (1973). A brief description of the program follows. The program consists of a main program and three subroutines. It performs three major functions: (i) storing the data, ii) assembling the data, and iii) analyzing the data. Decoded data cards are used as input; output consists of both printed tables and CALCOMP plotter analyses. The actual analysis is performed on the selected surface in two steps. First, the randomly placed data points are interpolated into a 21 x 21 grid which is centered over the center of the vortex. The grid is then passed to a second subroutine which produces analyses of D-values, isotachs, isotherms, and isodrosotherms. During this phase, six scans are made through the grid field with a maximum scan length of eight grid lengths. For the D-value analysis, reports from mandatory pressure levels only are used. However, analyses of the other parameters

are performed using data in the vicinity of a particular pressure altitude ($\pm$ 500 meters). Contouring intervals for all fields are adjustable.

For the purpose of this research, the program was adjusted so that the output covered a 200 x 200 n mi area with an interval grid spacing of 10 n mi. Once again only certain fields could be realistically studied due to the lack of sufficient data. The analyses, marked with an asterisk in Table III and shown in Figures 11–15, are representative of this aspect of the research and will be discussed in the following section.

Finally, calculations of the average radius of maximum wind (RMW) were conducted for both the tropical storm and hurricane stages. For the hurricane stage a total of 26 values from detailed eye messages were combined to yield an average maximum wind of 84 kt at an average distance of 23.5 n mi from the center of the vortex. Forty-four values were similarly processed for the tropical storm stage yielding averages of 41 kt at 27.4 n mi from the center. The quadrant or semi-circle containing the maximum wind was not treated separately. However, it is to be noted that most of the observations occurred in the front semi-circle. A comparison with the findings of Shea and Gray (1972) is found in the following section.

Table V is included as an aid in comparing the D-values relative to the U. S. Standard Atmosphere (used in this study) to D-values relative to a particular standard

tropical environment, namely a mean rainy-season tropical atmosphere of the Caribbean area (Riehl 1954). Shea and Gray employed a mean tropical atmosphere in their computation of D-values.

IV. RESULTS AND CONCLUSIONS

A. D-VALUE ANALYSES

D-values for the lower levels, shown in Figure 7, display a systematic decrease when approaching the center of the system. While the 700- and 850-mb profiles are not as smooth as those of Shea and Gray (1972), they still exhibit some similar characteristics. The slope of the 700-mb profile is nearly parallel to the North Atlantic curves for the 650-mb and 750-mb levels. The magnitudes of the D-values at the 850- and 700-mb levels are also similar to those of Shea and Gray at 900 and 750 or 650 mb, respectively. The 1000-mb profile in Figure 7 shows large negative D-values. The value at the vortex center converts to a sea-level pressure of 964 mb, indicative of moderate intensity. It should be noted from Figure 7 that the rather sharp gradients at 850 and 1000 mb in the 50-70 n mi band are likely to be erroneous. It is well known (Shea and Gray, 1972) that the maximum D-value gradients occur near the RMW, which, in this case, would be in the vicinity of the 24-n mi radius, on the average.

The fact that the 1000-mb, 850-mb, and 700-mb profiles in Figure 7 all approach nearly non-disturbed environmental conditions at radii greater than 70 n mi would indicate that the systems are small in horizontal extent.

Hansen (1972), using the concept of mean circular cloud diameter as a tropical cyclone descriptor on 40 recent tropical cyclones of the EASTROPAC, found that the mean circular cloud radius, and hence the radial extent of the tropical cyclone, was approximately 100 n mi. Thus, the results noted above agree in principle with the findings of Hansen.

A comparison of the radial profiles of tropical storms (Figure 8) with those of hurricanes (Figure 7) shows the upper levels, 500 mb and 300 mb, to be about the same in each case. The 700-, 850-, 1000-mb D-values at radii less than 60 n mi for the tropical storm case average 100, 200 and 225 meters higher than the hurricane values, respectively. Beyond 60 n mi the differences appear insignificant. These features would support the conclusion that most of the cyclonic activity occurs below the 500-mb level with the maximum intensification below 700 mb, as a tropical storm becomes a hurricane.

Figures 11 and 12 show the computer analyses of the 700-mb hurricane and tropical storm D-value fields, respectively. The actual report locations have been included to indicate the density of reports. The center of the composite system in each figure is the center of the plot with the direction of movement indicated by the arrows. It should be noted from Table III that these two fields contain the most reports of any of the fields

analyzed and yet, as the figures indicate, the coverage is rather sparse. The closed contours which are observed are not the result of meteorological phenomenon but the scarcity of data as the computer attempted to analyze the isolated reports. Several solutions to this problem are offered in Section V.

Due to geography and flight operations, investigations of EASTROPAC cyclones were usually carried out in the forward semi-circle with respect to movement, and most frequently in the right-front quadrant, as noted in Figures 11 and 12. Consequently, many of the contoured fields display a bias in the analyses, since the computer primarily analyzed to the initialized fields in some quadrants and to actual data in others. Figure 13 has been included to demonstrate this problem. The solution may lie in the investigation of the cyclonic system quadrant by quadrant vice all four quadrants at one time. The bias effect coupled with the paucity of data prohibited further analysis of the structure of the cyclone using this particular computer technique until initialization and contouring problems can be resolved.

B. ISOTACH ANALYSES

Figure 9 is the averaged wind speed vs radial distance from the vortex for the 700-mb surface compared with tangential wind speeds in the North Atlantic from Shea and Gray (1972). Shea's tangential winds represent

approximately 95 percent of the total wind speed at the 650- and 750-mb levels. Figure 16, from Shea and Gray, demonstrates that the radial variation of the wind field in hurricanes can assume many different forms. A large portion of the variability is due to the different radii of maximum winds (RMW) since the radial profile of the tangential wind outside the RMW seems similar in shape for many of the profiles. Thus, averaging winds without regard to the RMW evidently destroys some of the significance of the profile.

In general the 700-mb hurricane wind profile found in Figure 9 is quite flat except at the innermost and outermost radii. In the 0-10 n mi region,winds increase with increasing radii which is in agreement with Shea and Gray (1972). The rapid decrease in wind speed beyond 75 n mi is in agreement with the lower troposphere D-value profiles which indicate non-disturbed pressure gradients beyond 90 n mi. Since the RMW's were calculated from averaged detailed eye data only whereas the 700-mb winds were obtained from composite radially averaged data, the peak wind positions in Figure 9 were not expected to coincide with the RMWs. Although the EASTROPAC isotach results shown here indicate higher wind speeds than those of the North Atlantic, not too much significance can be attached to them in view of the sparsity of data.

The 700-mb isotach profile for tropical storms is also included in Figure 9. While the shape of this profile

is not informative, it is of interest to compare the hurricane and tropical storm profiles which show that the average 700-mb wind increased 40-50 kt with intensification from tropical storm to hurricane stage. This value is compatible with the 43-kt increase in maximum surface wind intensity.

Figures 14 and 15 have been included to show the computer analyses of the 700-mb isotach data for the tropical storm and hurricane stages. Once again little information was obtained by this method due to problems already cited.

C. ISOTHERM ANALYSES

Figure 10 is a comparison of the 3000 $\pm$ 500-meter and the 9200 $\pm$ 500-meter isotherm fields with North Atlantic temperature fields as averaged with respect to radius. The Shea and Gray (1972) temperatures are the observed temperatures adjusted to a constant pressure surface using typical hurricane lapse rates. The isotherm values in this study are radial averages of those data points found within $\pm$ 500 meters of the specified pressure altitude. Since there is a fairly even distribution of points above as well as below the specified level, it would seem valid to compare these values with those of Shea and Gray (1972).

As Figure 10 indicates the 700-mb isotherm profile did indeed compare favorably with the results of Shea and Gray (1972). Of more interest, however, is the comparison of

the EASTROPAC tropical storm and hurricane stages. It is noted that the inner-core temperature increases about 6C with intensification from tropical storm to hurricane stage at 700 mb. However, this temperature increase tapered off until, at approximately 30 n mi and beyond, the two stages exhibited similar characteristics, considering that the hurricane data at the 50-n mi arc was a function of two observations, both of which were subjectively considered to be not representative. This feature coupled with the fact that the average RMW was found to be 23.5 n mi for the hurricane stage would support the findings of other investigators (e.g. LaSeur, 1966) that the maximum warming at lower levels in hurricanes is confined to the inner-core region.

LaSeur (1966), as seen in Figure 17, shows a thin layer of relatively warm air at large cyclone radii, evidently produced by outflowing relatively warm air in the upper troposphere. The 300-mb hurricane isotherm field of Figure 10 displays a similar warming trend to a radius of 90 n mi in relation to the tropical storm profile which may be taken as antecedent conditions. These facts are interpreted to indicate outflow of warm air from the core region at 300 mb. Insufficient isotherm data were available to check the vertical depth of this upper-level warm outflow. Thus, it is not possible at this point in the research to postulate whether the outflow layer for

EASTROPAC cyclones occurs at a significantly different level than typhoons or hurricanes.

The computer plots of temperature were searched for an upper-tropospheric warm area in the direction of storm motion, as found by Shea and Gray (1972). None was found, which, as before, may be a function of the scarcity of data.

D. RADIUS OF MAXIMUM WIND

Figure 18, from Shea and Gray (1972), shows that the RMW for moderate Atlantic hurricanes lies generally within the 15–30 n mi range. The RMW of intense storms was less than 15 n mi and that of weak storms was generally greater than 30 n mi. The value of 23.5 n mi found for EASTROPAC hurricanes would classify them with moderately intense Atlantic hurricanes. This is in agreement with the findings of Hansen (1972) who concluded that EASTROPAC cyclones are relatively weak and limited in development.

V. SUGGESTED TOPICS FOR FUTURE RESEARCH

1. In connection with the composite radial technique, reanalysis of data with respect to the radius of maximum wind should be carried out where sufficient Detailed Eye Reports exist. A comparison of these results with those of Shea and Gray (1972) could then be made.

2. In an effort to smooth the computer analyses, several approaches might be attempted. One method would involve changing the form of the initialization fields prior to griding. For example, the values generated by composite radial calculations might be used in the initial grid fields. Along similar lines, fields generated at the tropical storm stage could be used to initialize the hurricane stage. A second approach would involve covering the 200 x 200-n mi analysis area with an 11 x 11 grid versus the 21 x 21 grid. In data sparse areas, this would help eliminate excessive gradients which can develop around isolated data points, since the data points would be interpolated over a larger area.

3. In an attempt to resolve the bias problems encountered, it is suggested that the cyclones be analyzed quadrant by quadrant. Further, it is suggested that the right-front quadrant or right semi-circle be studied first.

4. Sheets (1969) found that various parameters in the tropical-cyclone soundings were a function of the sea-level

pressure (SLP) so that he was able to stratify the data by ranges of SLP to obtain mean soundings for each range. This approach might be tried with dropsonde reports as a means of investigating EASTROPAC cyclone structure.

5. Ship-reported data and satellite-interpreted tropical cyclone data should be obtained and used in extending the research on EASTROPAC cyclones.

6. In order to manufacture tangential wind (V) profiles from minimal data along each radius (r), wind formulations such as Vr^x = constant could be used to extrapolate winds to either side of a data point (Riehl, 1954). Shea and Gray (1972) found the exponent (x) to be .47 ($\pm$ .3) outside the RMW and −1.05 ($\pm$ .6) within the RMW at levels between 900 and 500 mb.

7. Finally, periodic reanalysis of the data should be carried out, since the data base will expand significantly with each additional season of aircraft reconnaissance reports.

TABLE I. The number of weather reconnaissance flights, 1966–1972 as reported in publication sources versus those actually acquired by author. (All stages of tropical cyclones included)

Year	FWC/JTWC Typhoon Report	Monthly Weather Review	Mariner's Weather Log	Flight data acquired
1966	10	–	11	14
1967	20	–	6	18
1968	5	7	0	10
1969	26	30	28	15
1970	53	54	54	49
1971	60	62	63	64
1972	26	46	46	63
				233

TABLE II. Summary of reconnaissance–flight information information (1966–1972) and individual Detailed Eye Reports believed to exist but not available to author. (hurricane and tropical storm stages only)

Year	Flights	Detailed Eye Reports
1966	1	14
1967	1	12
1968	6	4
1969	14	3
1970	1	0
1971	0	0
1972	2	1
	25	34

TABLE III. Summary of the number of data points used in the analysis, (1966–1972) by level and parameter. (The analyses marked with an asterisk appear as Figures 11–15.)

	Stage	
	Tropical Storm	Hurricane
3000 ± 500 meters		
Isotach	52*	23*
Isotherm	90	53
Isodrosotherm	44	22
5600 ± 500 meters		
Isotach	4	7
Isotherm	16	11
Isodrosotherm	9	4
7200 ± 500 meters		
Isotach	4	2
Isotherm	15	7
Isodrosotherm	13	5
9200 ± 500 meters		
Isotach	17	8
Isotherm	28	11
Isodrosotherm	0	0
D–Value Analyses		
1000	54	20
850	65	33
700	117*	73*
500	18	10*
400	4	2
300	51	19
200	5	3

TABLE IV. Number of D-values averaged at each radial distance for use in generating hurricane (tropical storm) profiles.

Radial Distance (n mi)	Pressure Surface (mb) 1000	850	700	500	300
0	4(12)	7(14)	26(40)	3(7)	3(8)
10	7(13)	12(16)	13(15)	0(3)	1(7)
20	1(7)	1(5)	5(19)	0(2)	3(6)
30	4(4)	3(7)	5(10)	1(0)	0(7)
40	0(6)	4(5)	5(9)	0(0)	3(2)
50	1(3)	2(4)	5(6)	0(0)	2(1)
60	0(1)	0(1)	3(3)	1(2)	1(3)
70	1(1)	1(4)	3(4)	1(0)	0(4)
80	1(3)	1(3)	3(6)	1(1)	4(5)
90	0(2)	2(3)	4(2)	1(2)	1(4)
100	1(2)	0(3)	1(3)	2(1)	1(4)

TABLE V. Comparison of the United States Standard Atmosphere with a mean rainy-season tropical atmosphere (Riehl, 1954) for selected levels.

Level (mb)	Height (m) United States Standard	Rainy-Season Tropical
1000	110	120
900	990	1040
850	1460	1510
800	1950	2050
700	3010	3170
600	4200	4430
500	5570	5870
400	7180	7580
300	9160	9670
200	11790	12400

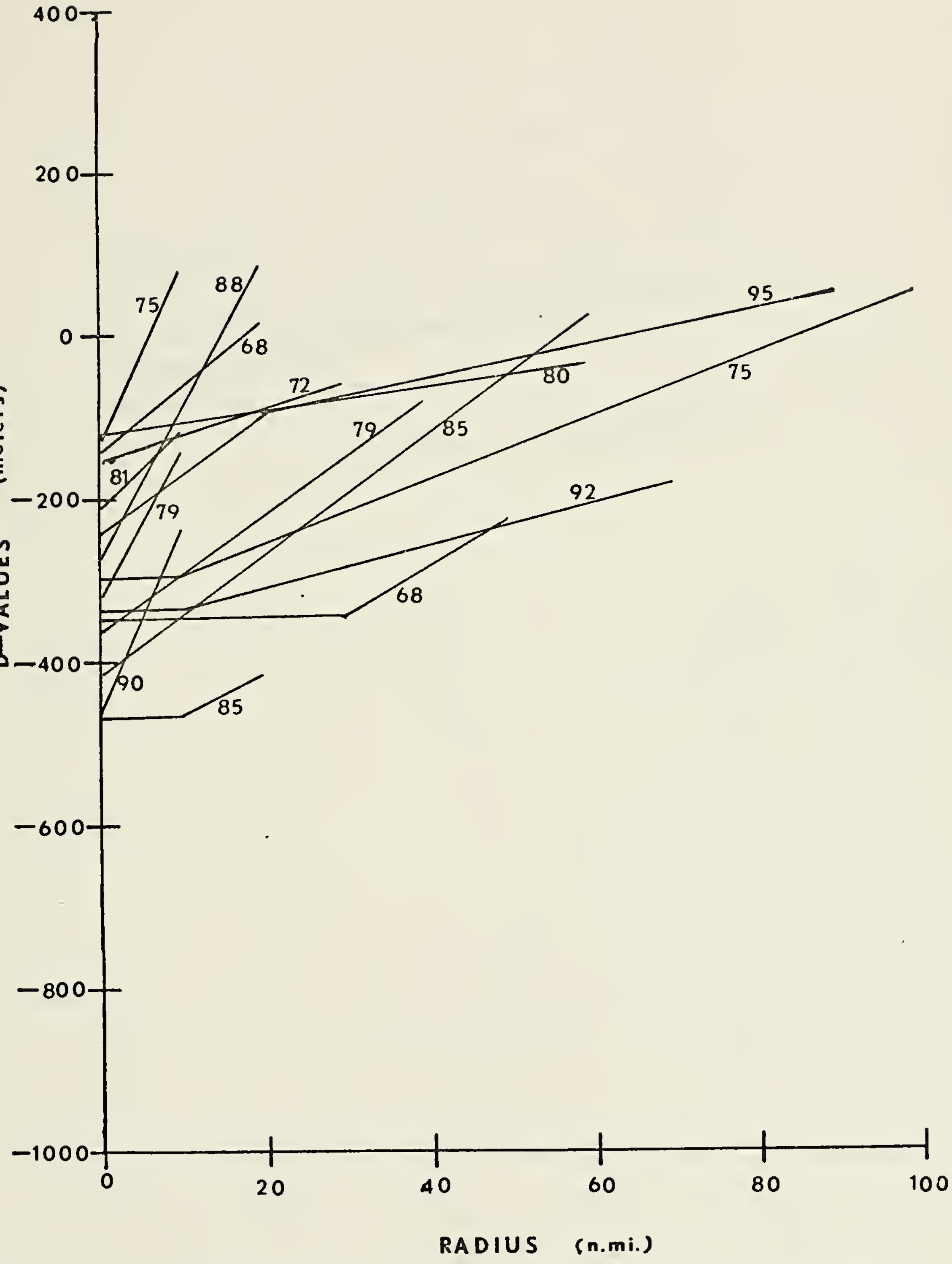


Figure 1. 700—mb linear D—value profiles for individual reconnaissance missions; hurricanes only. (Numbers indicate maximum surface winds at observation times.)

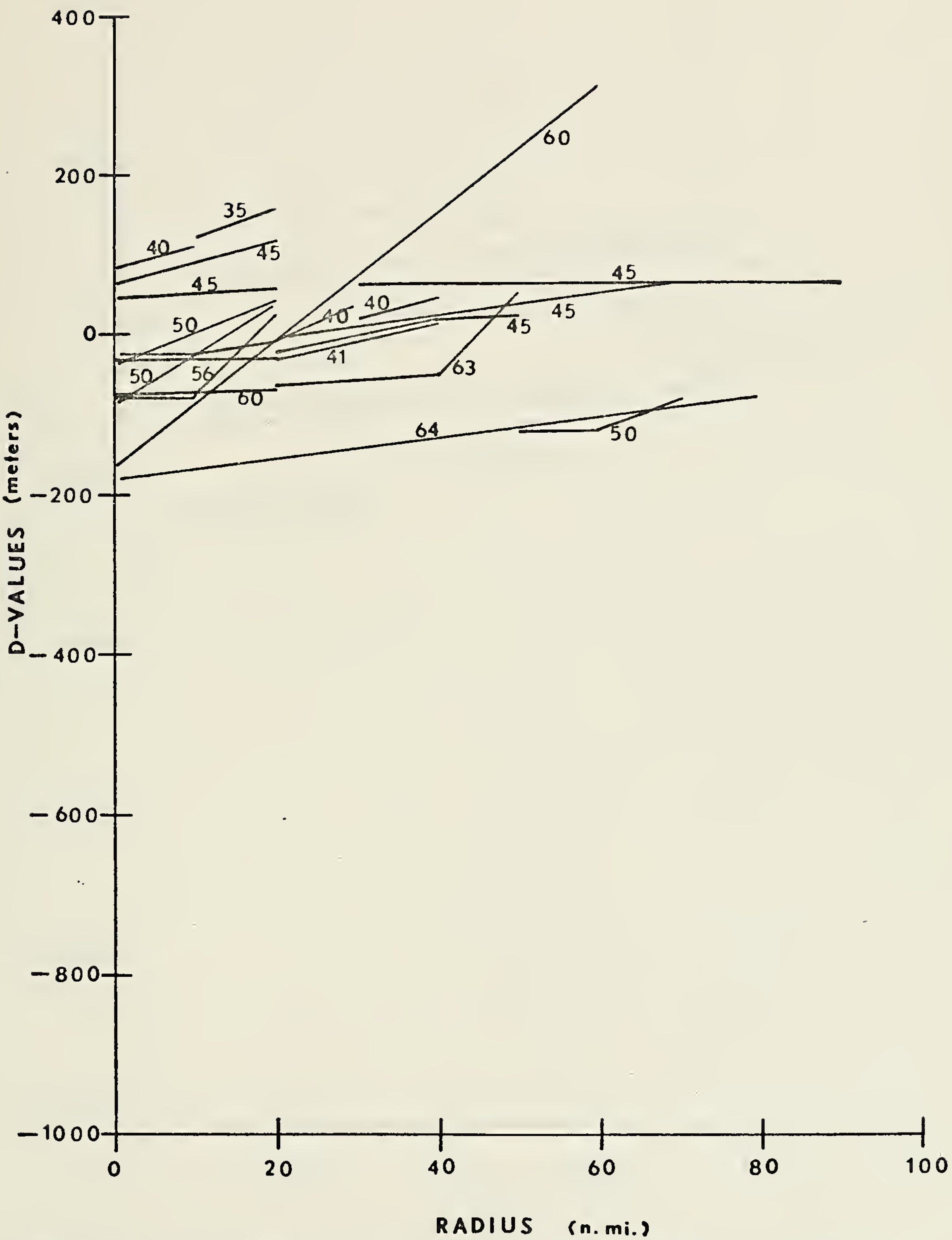


Figure 2. 700-mb linear D-value profiles for individual reconnaissance missions; tropical storms only. (Numbers indicate maximum surface winds at observation times.)

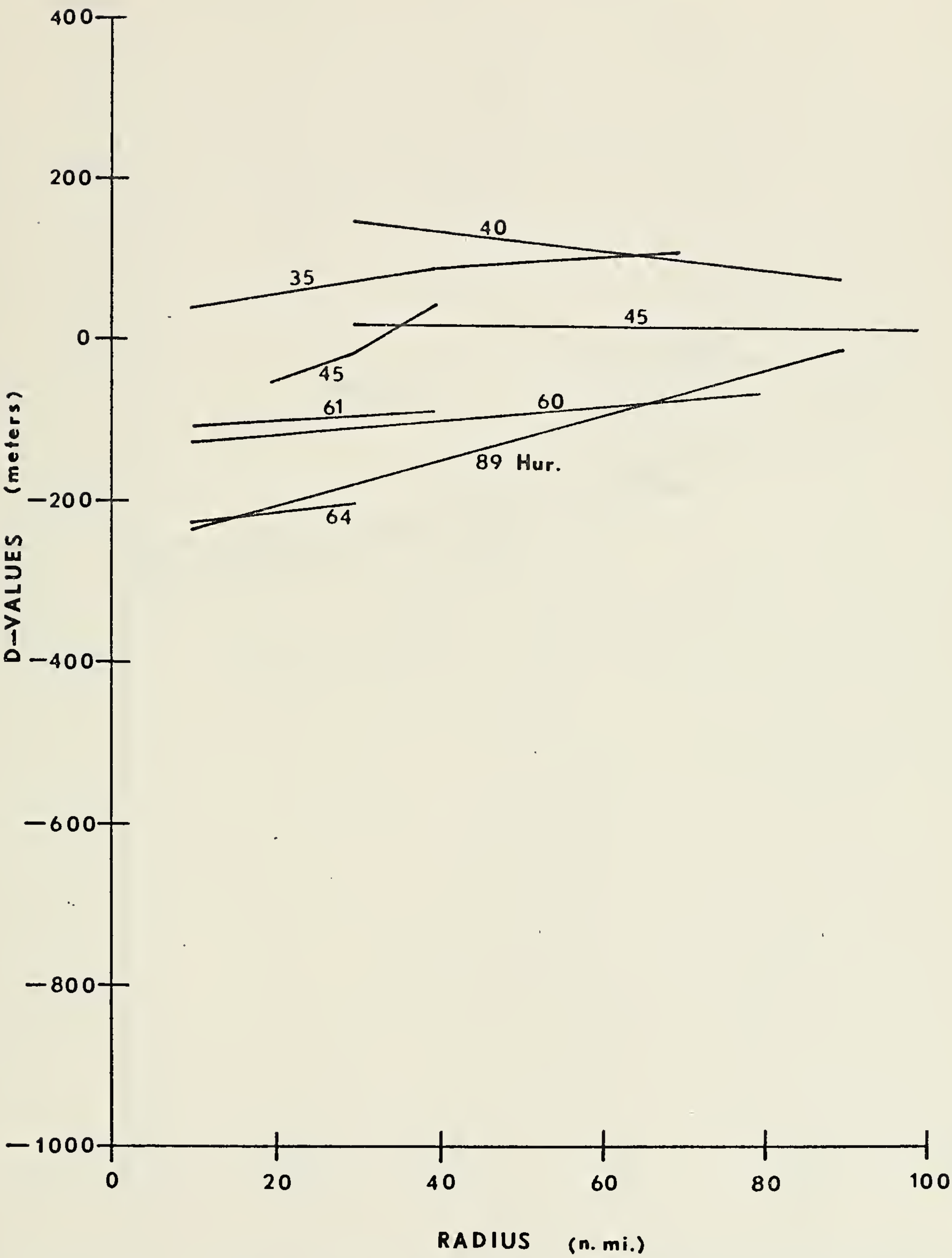


Figure 3. 850—mb linear D—value profiles for individual tropical storms and one hurricane. (Numbers indicate maximum surface winds at observation times.)

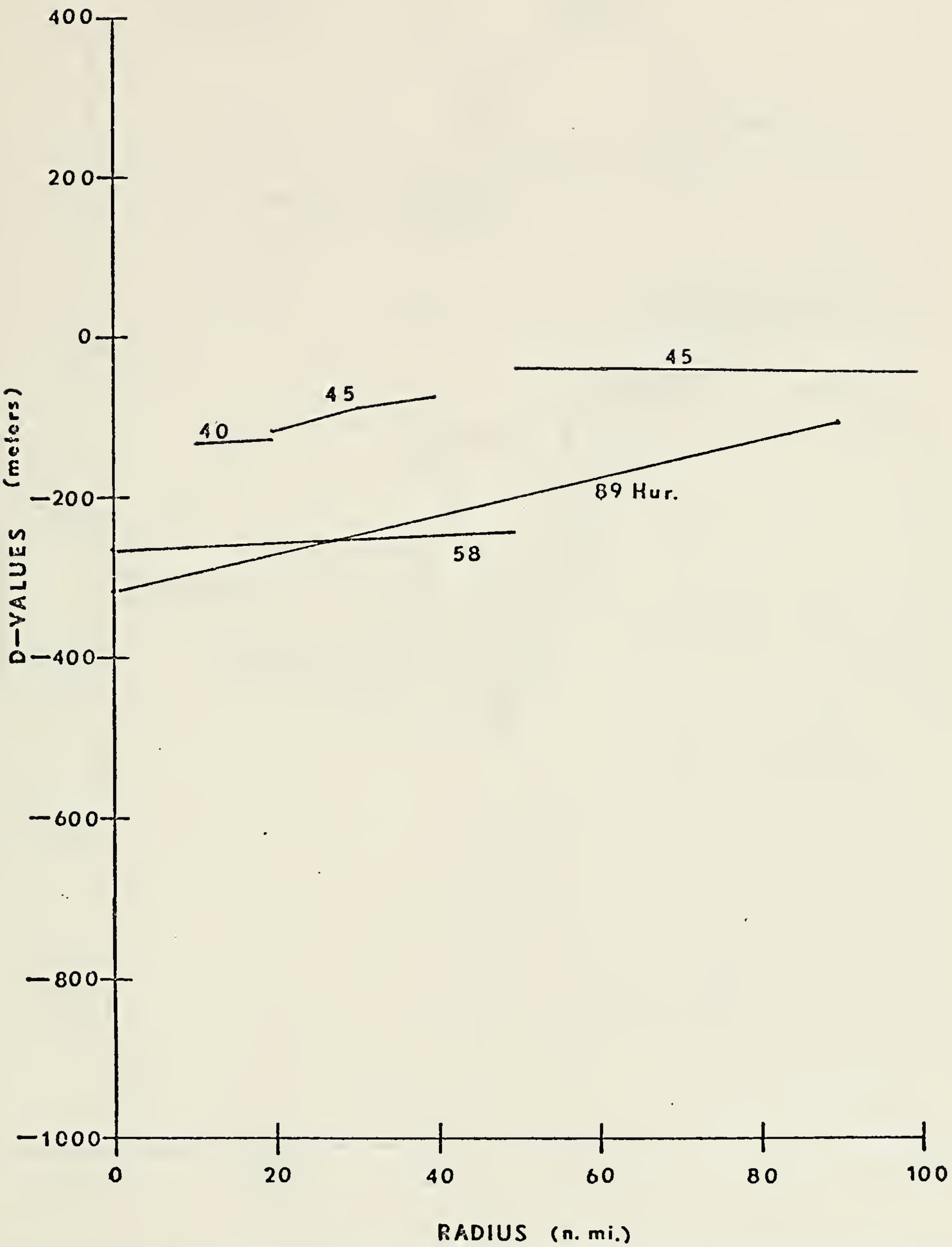


Figure 4. 1000–mb linear D–value profiles for individual tropical storms and one hurricane. (Numbers indicate maximum surface winds at observation times.)

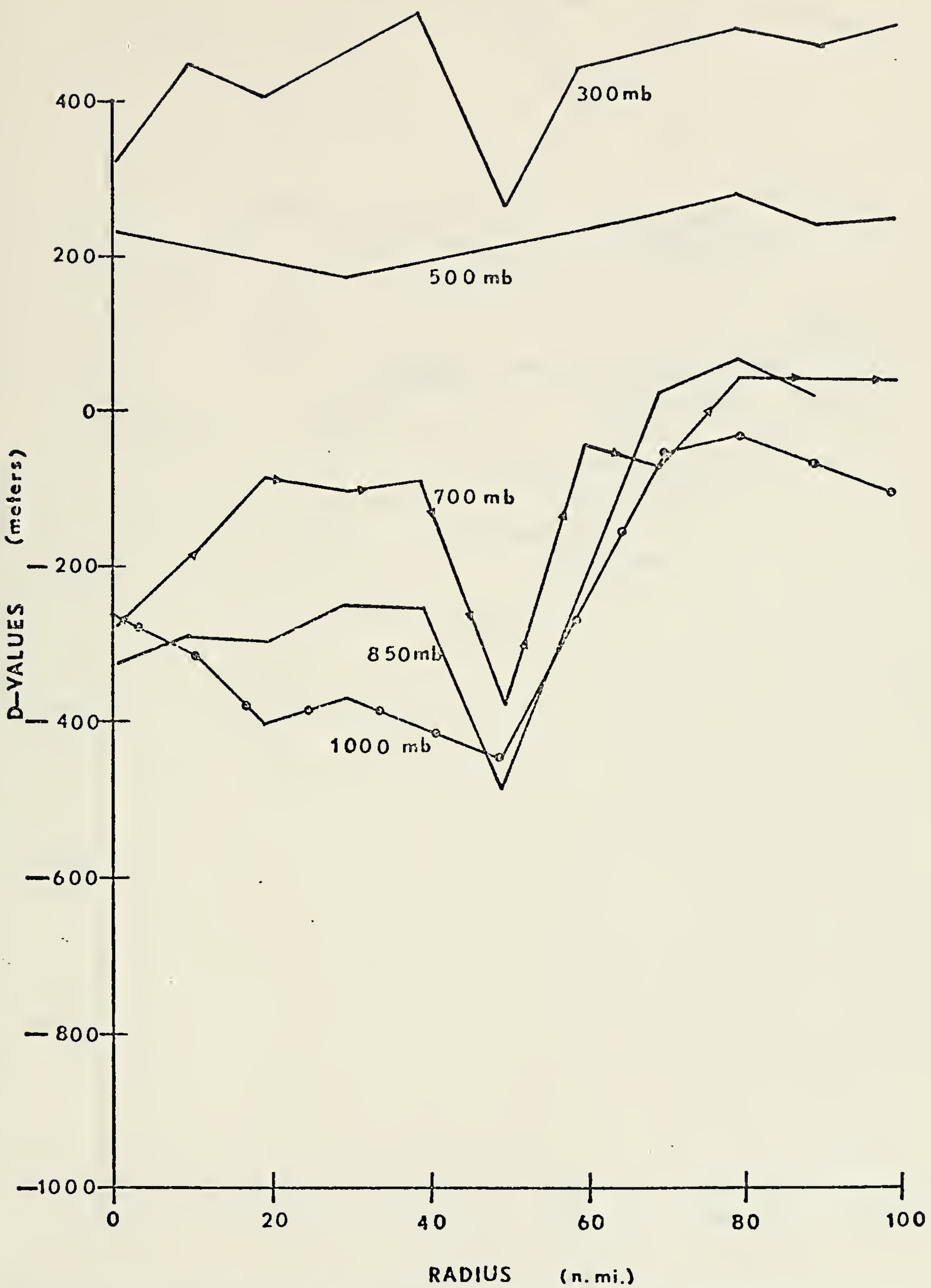


Figure 5. Unmodified composite hurricane D—value profiles.

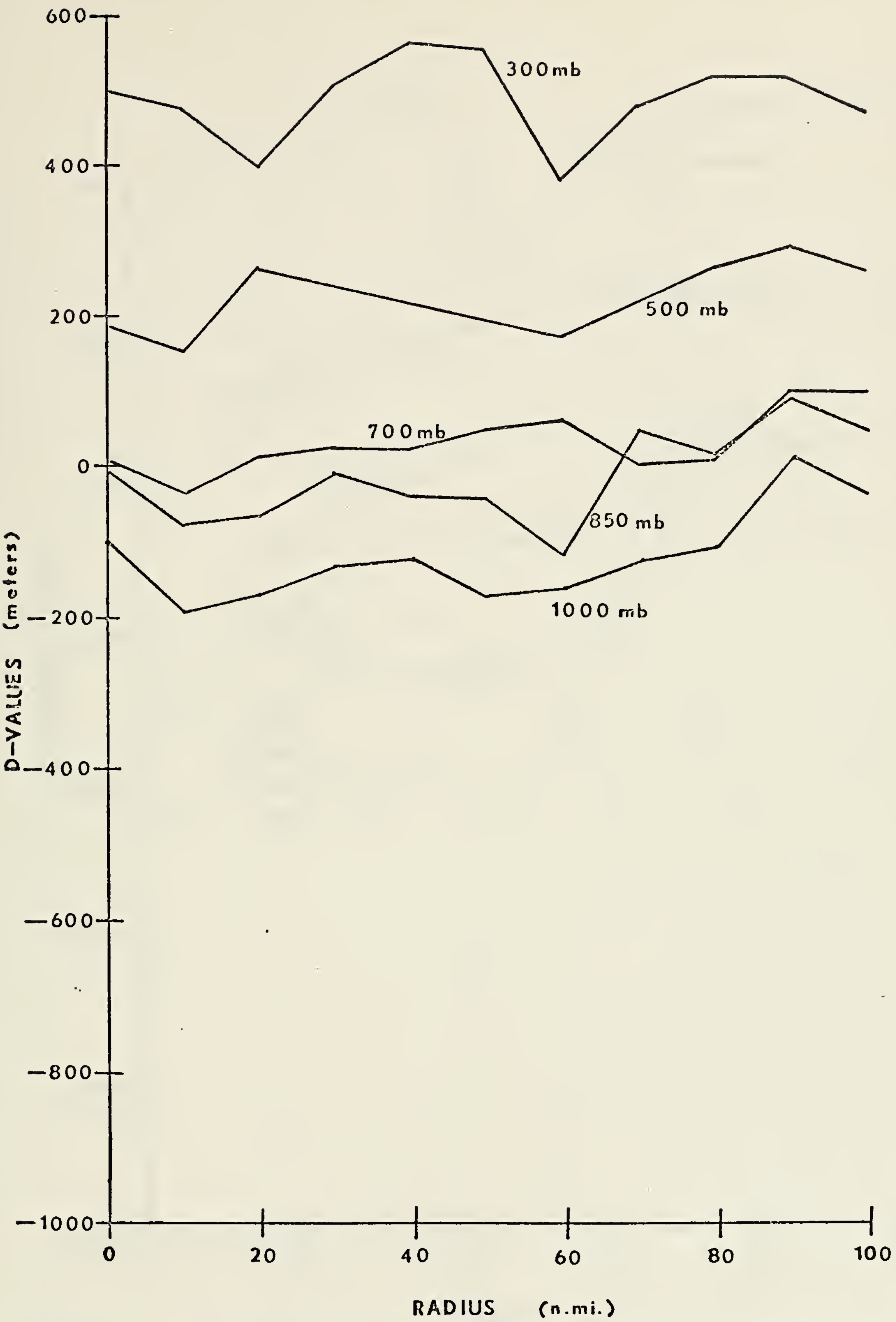


Figure 6. Unmodified composite tropical storm D-value profiles.

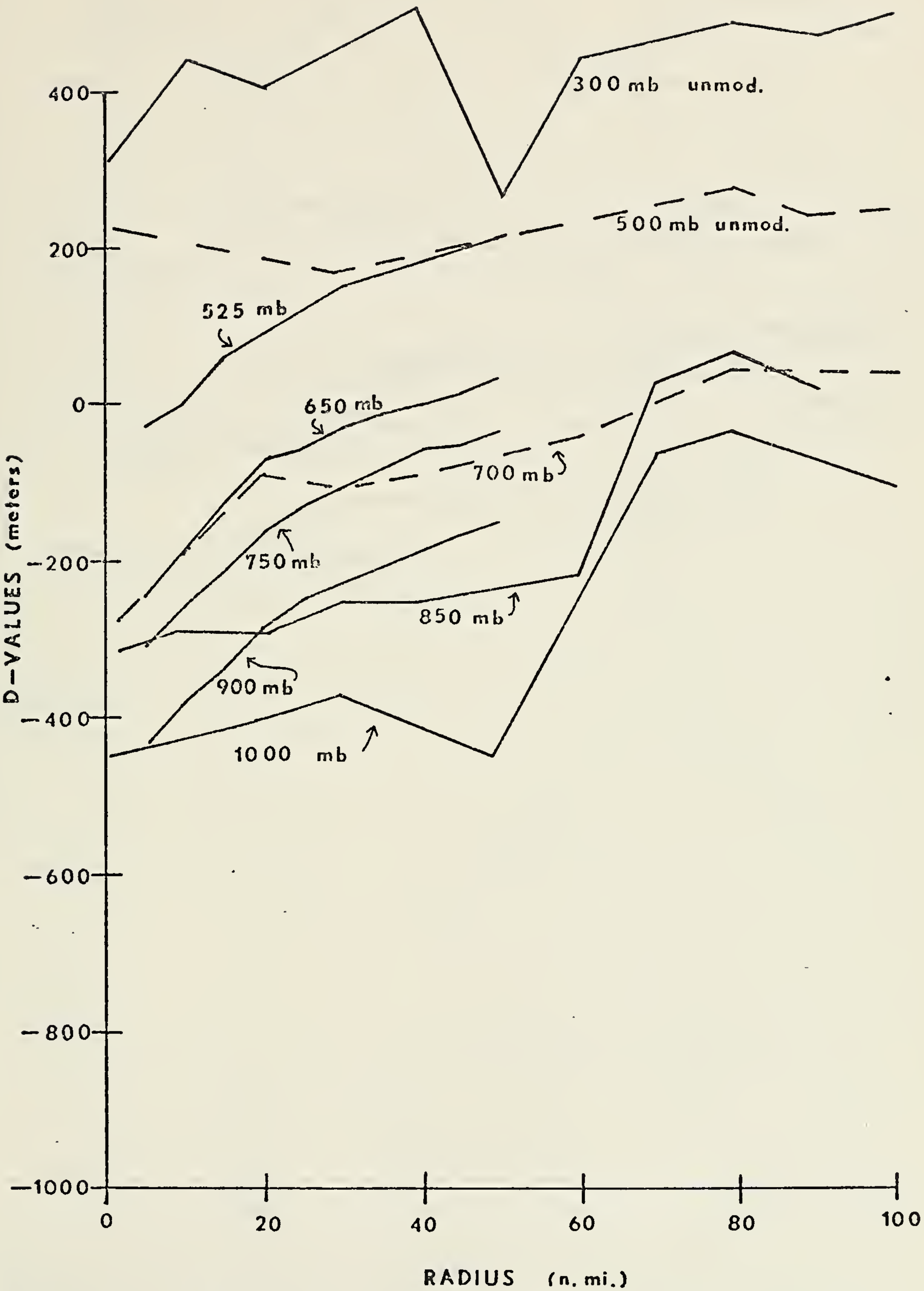


Figure 7. Selectively modified hurricane D-value profiles in EASTROPAC (1000,850,700,500,and 300 mb) vs D-values in the North Atlantic (900,750,650,525 mb)(Shea and Gray,1972).

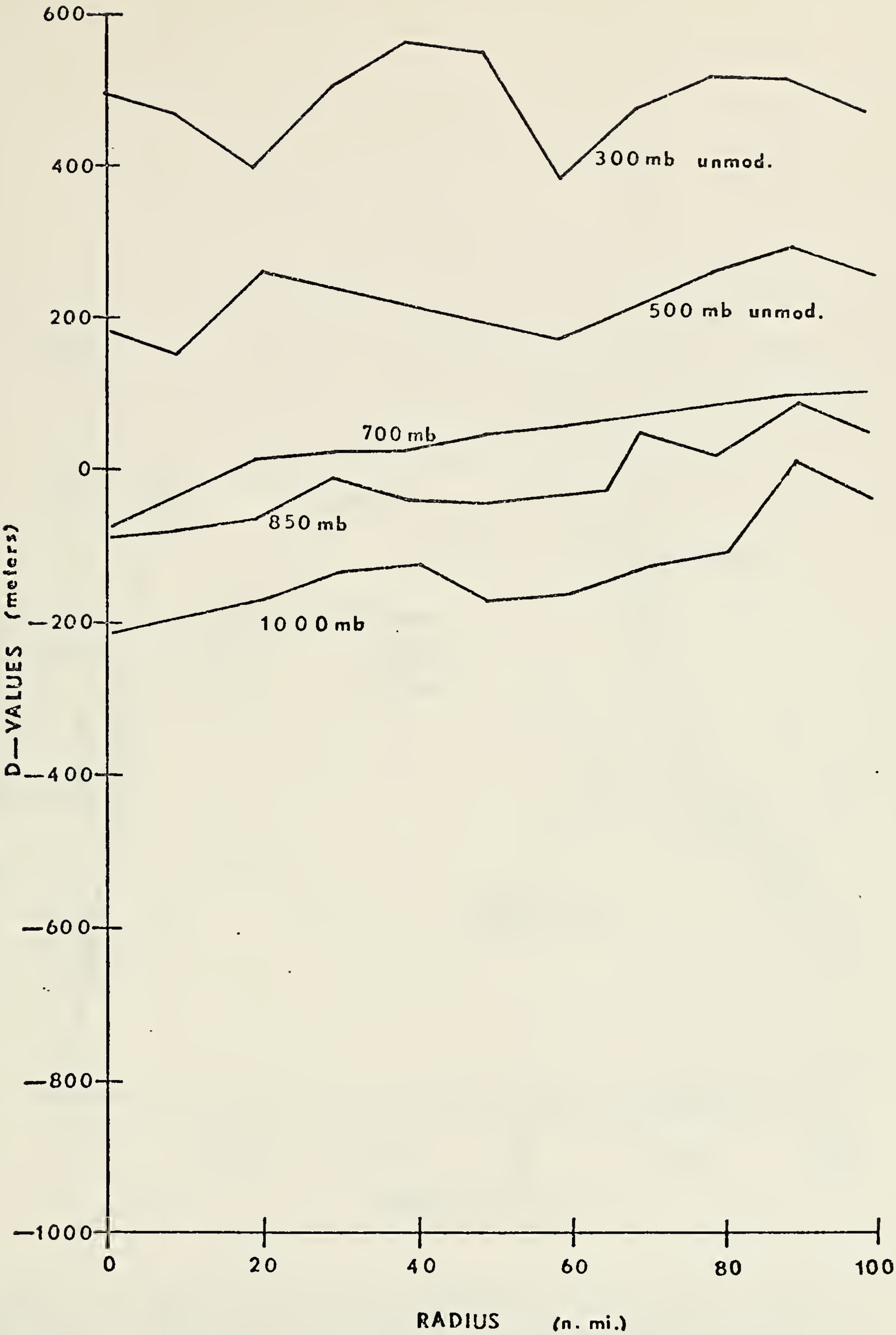


Figure 8. Selectively modified tropical storm D-value profiles.

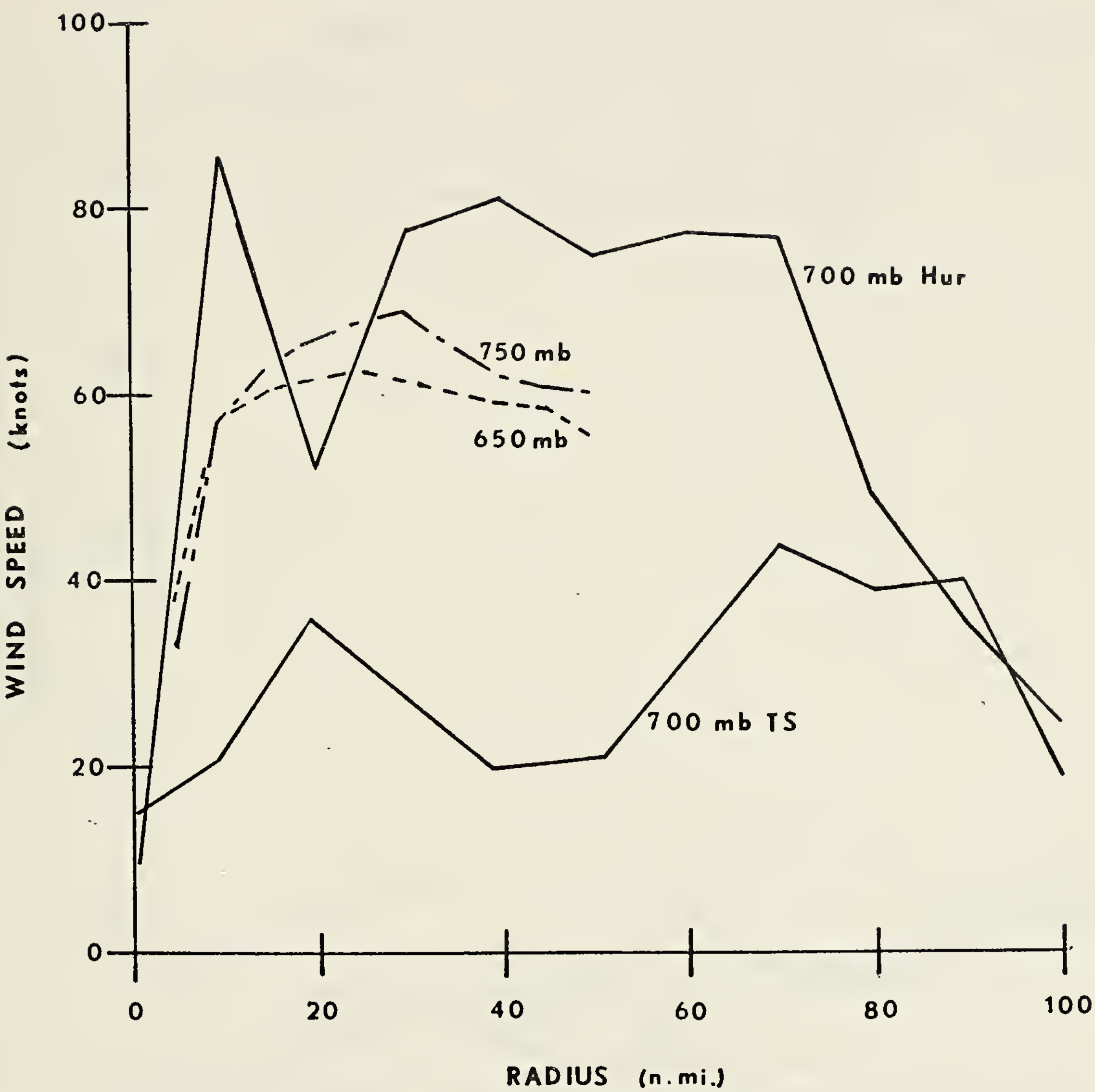


Figure 9. Radially averaged EASTROPAC 700—mb wind speeds vs 750— and 650—mb tangential hurricane wind speeds in the North Atlantic. EASTROPAC wind information from geometric levels within 500 m of 700 mb.

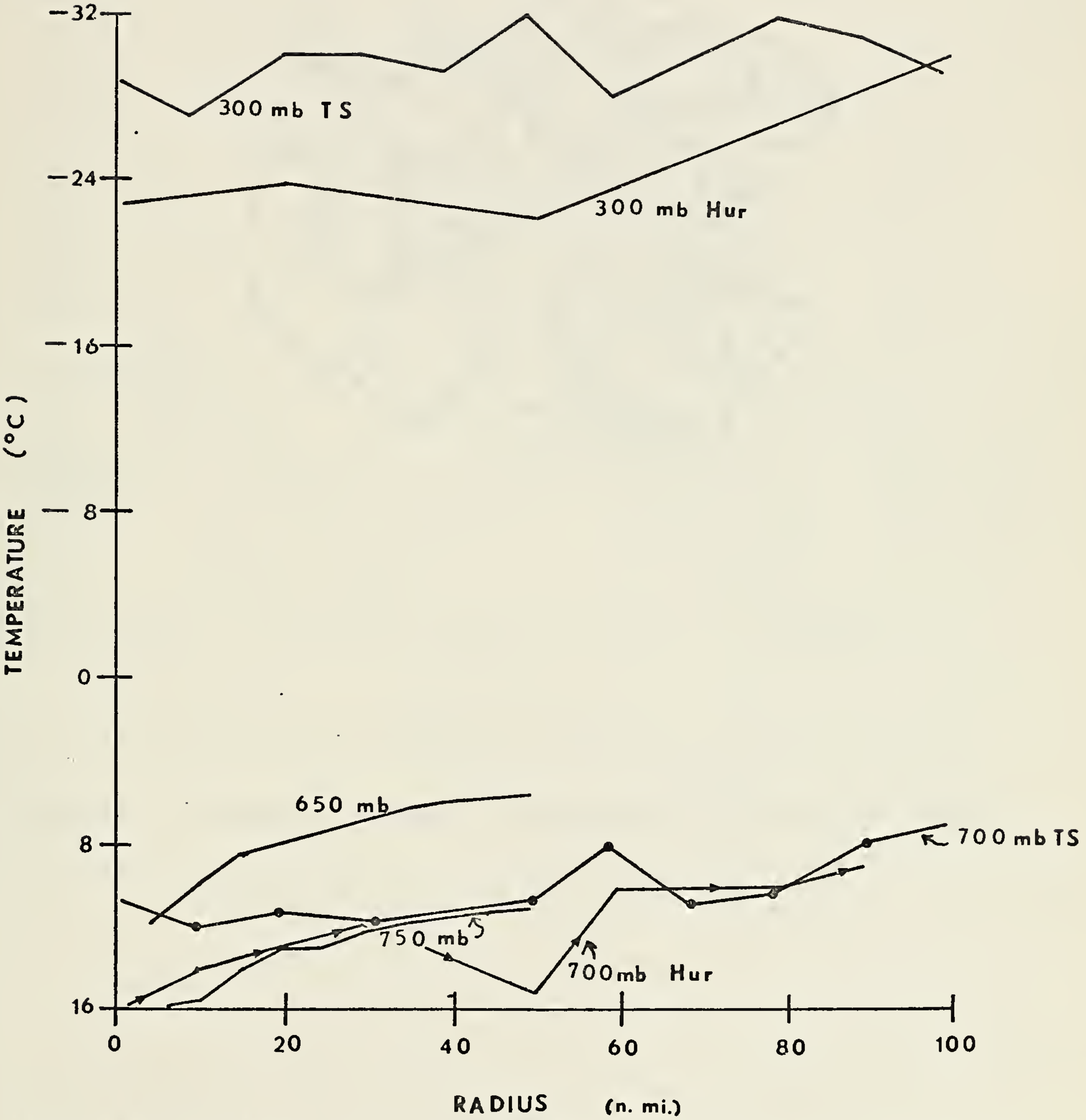


Figure 10. Radially averaged EASTROPAC 700- and 300-mb temperature profiles vs North Atlantic 650- and 750-mb temperature profiles of Shea and Gray (1972). EASTROPAC temperature information for geometric levels within 500 m of 300 and 700 mb.

Figure 11. 700-mb hurricane D-value field (60-m intervals).

Figure 12. 700-mb tropical storm D-value field (60-m intervals).

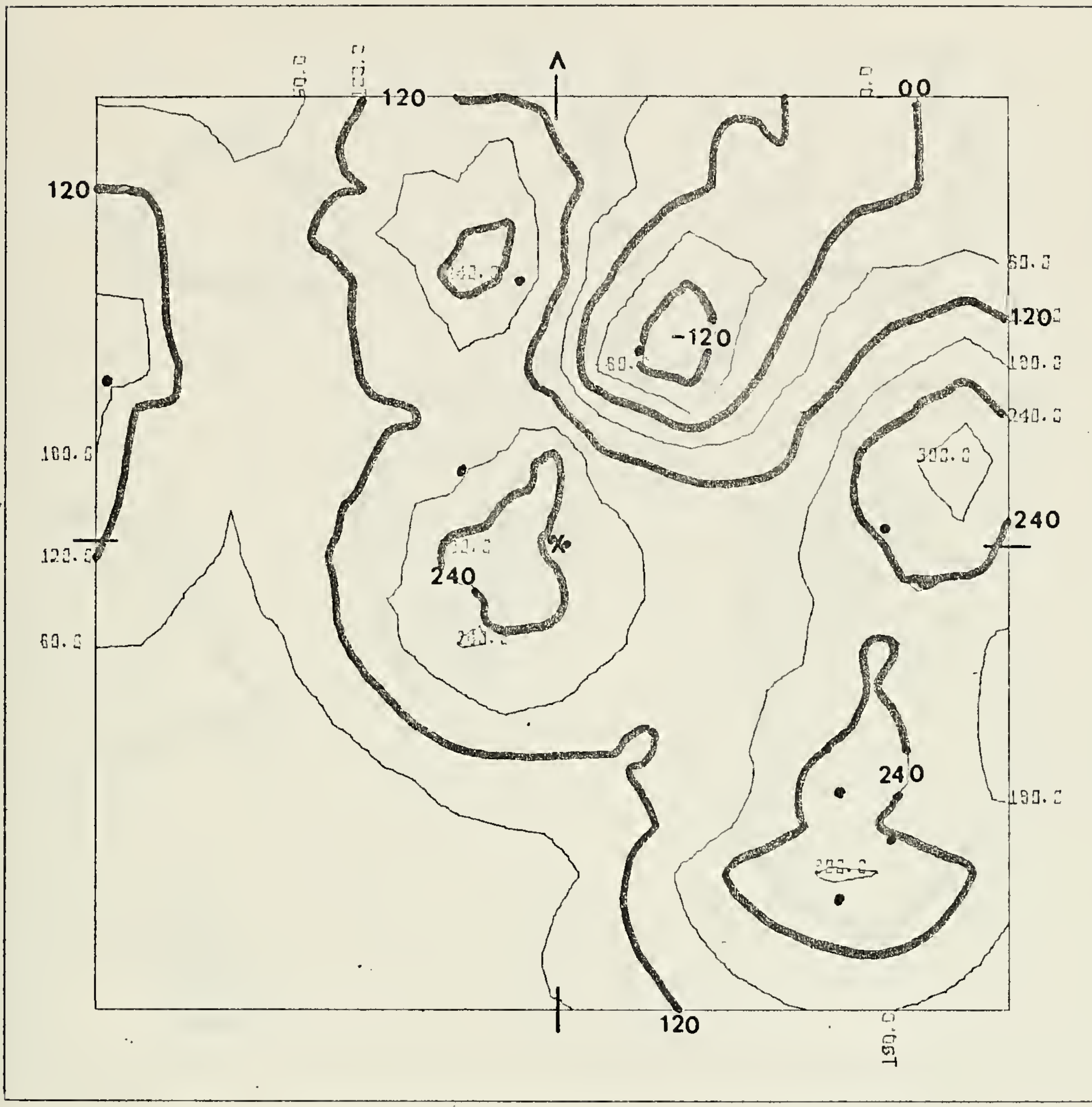


Figure 13. 500-mb D-value field which demonstrates the data bias problem (60-m intervals).

Figure 14. 700–mb tropical storm isotach field. (10–kt intervals).

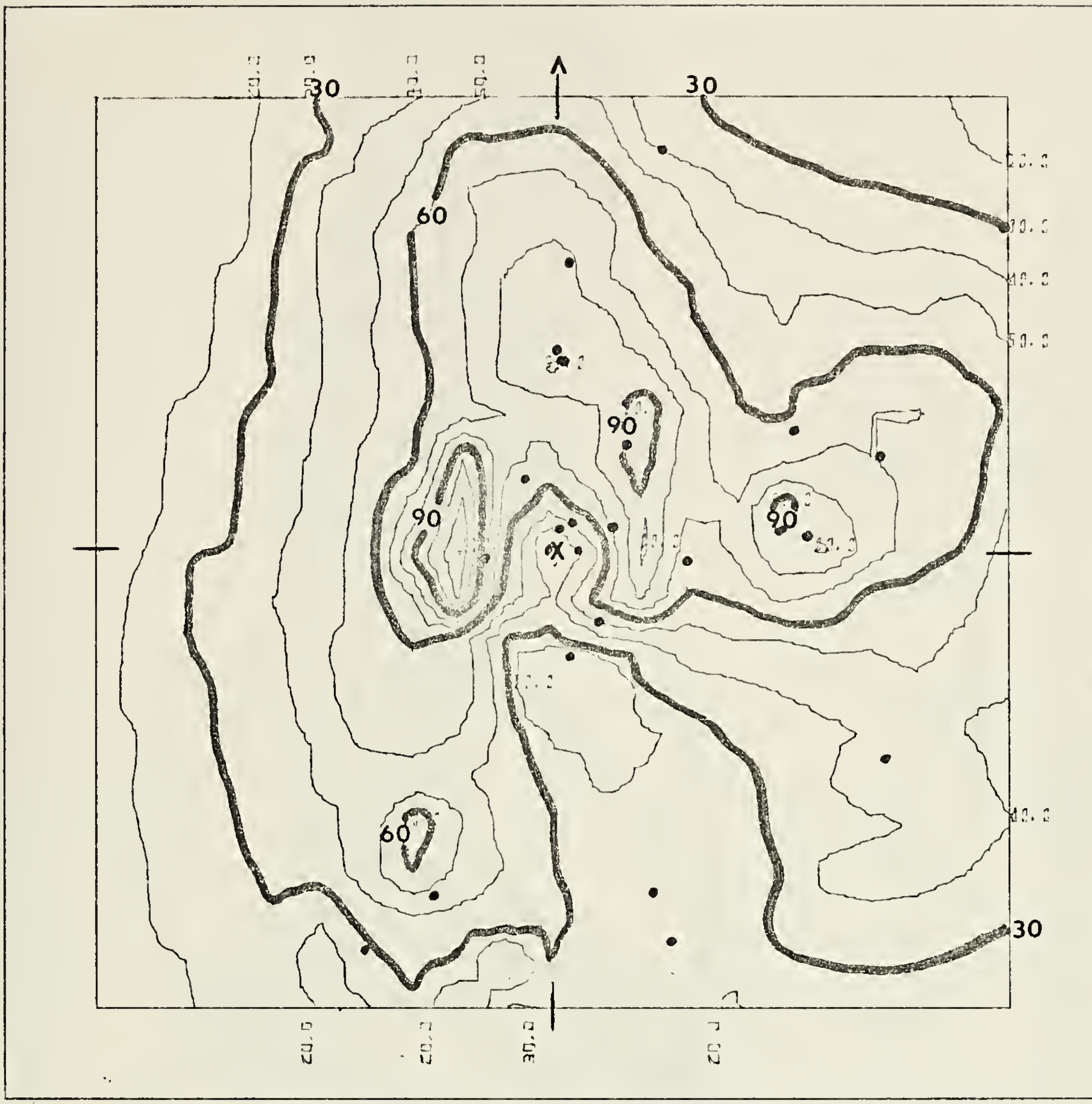


Figure 15. 700-mb hurricane isotach field.
(10-kt intervals)

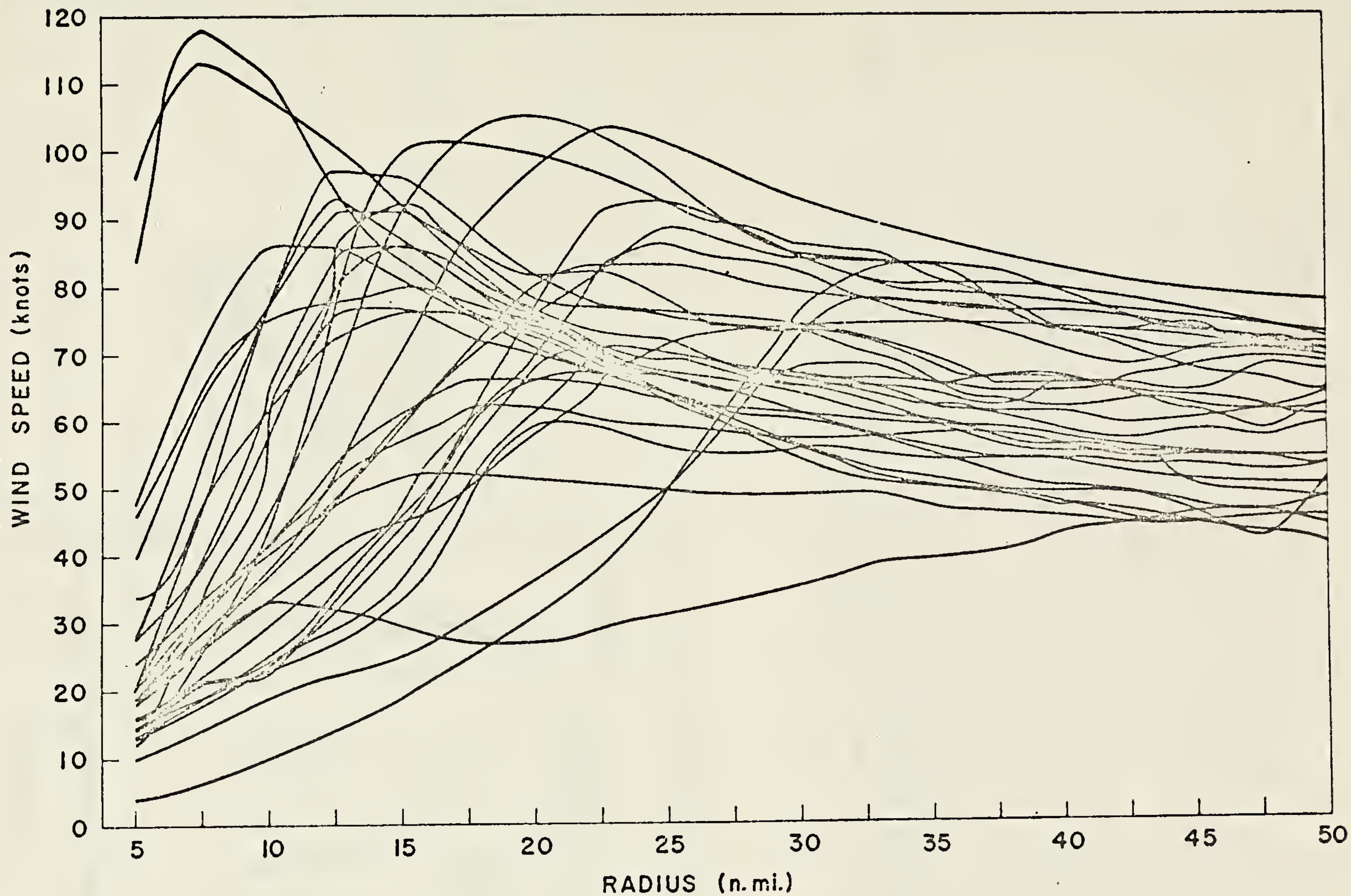


Figure 16. Sample of observed tangential wind profiles for the North Atlantic area (Shea and Gray, 1972).

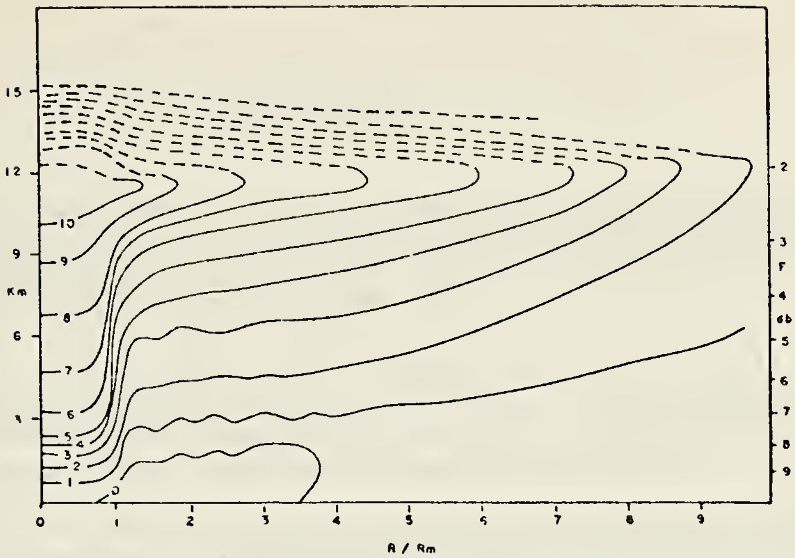
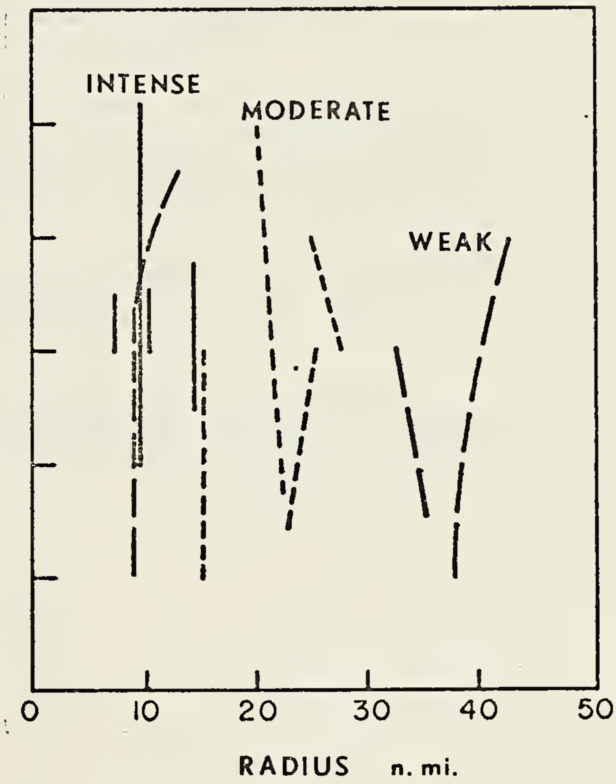


Figure 17. Schematic model of the departure of hurricane temperatures from the undisturbed tropical atmosphere (LaSeur, 1966).

Figure 18. Variation of the RMW with elevation for hurricanes with two or more simultaneous flights, in lower troposphere only (Shea and Gray, 1972).



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Over 225 aircraft reconnaissance missions (1966-1972) into eastern North Pacific tropical (EASTROPAC) cyclones (tropical storms and hurricanes only) are computer processed and analyzed to present a composite view of the near-center cyclone structure. Radially-averaged profiles of D-values, isotherms, and isotachs are related to similar information from North Atlantic and western North Pacific tropical cyclones.

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A two-dimensional analysis of these parameters does not appear advantageous at this time due to the scarcity and distribution of data.

The analyses qualitatively indicate that EASTROPAC cyclones are small in horizontal extent while relatively intense for their size, the latter feature comparing favorably to the average North Atlantic tropical cyclone. Maximum warming occurs within the radius of maximum wind (which averages 24 n mi) at lower levels with cyclone-induced warming evident to a radius of 90 n mi at upper levels. Other features are shown and suggestions for future research discussed.

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